Answers 2011-06-10

13. A rock contains 257 mg Pb-206 for every gram U-238.

Number of U atoms today = 1 g = $1/238 * N_A = 2.53025 \times 10^{21}$.

Number of Pb atoms today = $0.257/257 * N_A = 6.022 \times 10^{20}$.

All Pb originates from U-238,

- ⇨ At t(0) the number of U atoms is $2.53025 \times 10^{21} + 6.022 \times 10^{20} = 3.13245 \times 10^{21}$.

$N = N_0 e^{-\lambda t} \Rightarrow t = -1/\lambda * \ln(N/N_0) = -4.5 \times 10^9/\ln(2) * \ln(2.53025 \times 10^{21}/3.13245 \times 10^{21}) = 1.39 \times 10^9$ years

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14. Isotope dilution.

Unknown weight can be obtained from $w_u = (S_0/S_m - 1) * w_0$ [see Lecture 5 notes]

$w_0 = 4.30$ gram, $S_0 = 8700$ Bq/g

Activity is measured to be 191.1 cps, $\eta = 75.2\%$ => A = 254.1 Bq

Specific activity Sm = 254.1/2.1 = 121.0 Bq/g

$w_u = (8700/121-1)*4.3 = 304.85$ gram

Amount of naphthalene in tar = 304.84/630 = 48.4%

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15. After irradiation we have three radioactive nuclides, X-101, X-103 and Y-103.

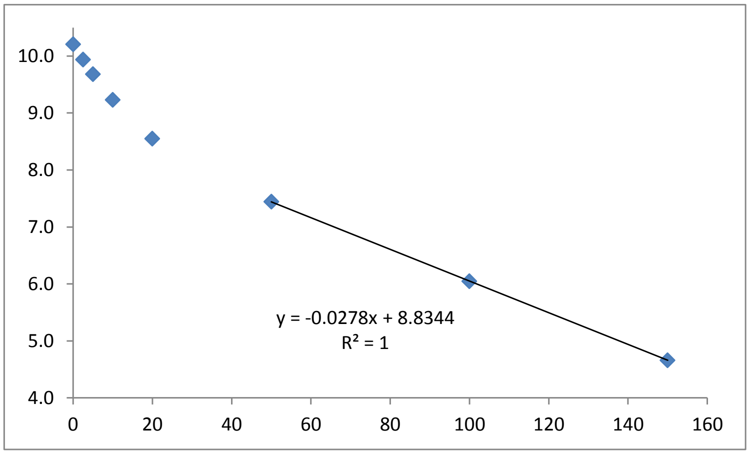
Amount and half-life is known for X-101. Then activity of X-101 can be calculated for the different times.

$A_{0,\,X\text{-}101} = N \times \lambda = 1.9612 \times 10^{-13}/101 \times 6.022 \times 10^{23} \times \ln 2/(200 \times 3600) = 540.76$ Bq

$A_{0,\,X\text{-}101} = A_{0,\,X\text{-}101} \times e^{-\lambda t}$

Time [h]	Activity [Bq]	$A_{X\text{-}101}$	Remaining A	ln (remain A)
0	28 168.23	1 125.7	27 042.5	10.21
2.5	21 765.35	1 116.0	20 649.4	9.94
5	17 132.78	1 106.4	16 026.4	9.68
10	11 281.43	1 087.4	10 194.1	9.23
20	6 200.90	1 050.3	5 150.6	8.55
50	2 656.57	946.6	1 710.0	7.44
100	1 218.56	796.0	422.6	6.05
150	774.99	669.4	105.6	4.66

Take natural logarithm of remaining activity and plot vs time. The last three points five a straight line with slope = $-\lambda$



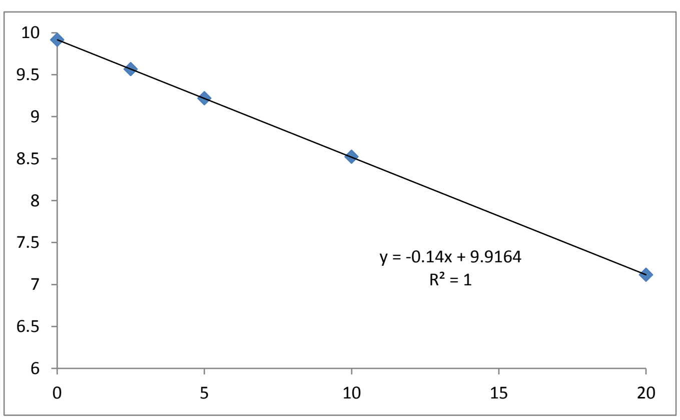
⇨ λ=0.0278 => $t_{½}$ = 24.9 h. This must be the half-life of Y-103 (daughter more long-lived than mother)

Since the three last points only contain Y-103 you can calculate the activity of Y-103 for the different times ($A=A_0e^{-\lambda t}$)

Time [h]	Activity [Bq]	A_{X-101}	A_{Y-103}	Remaining A	Ln Rem. A
0	28 168.23	1 125.7	6 836.5	20 206.0	9.913737
2.5	21 765.35	1 116.0	6 377.5	14 271.9	9.566046
5	17 132.78	1 106.4	5 949.3	10 077.1	9.218023
10	11 281.43	1 087.4	5 177.2	5 016.8	8.520553
20	6 200.90	1 050.3	3 920.7	1 229.9	7.114663
50	2 656.57	946.6	1 702.8	0	
100	1 218.56	796.0	424.1	0	
150	774.99	669.4	105.6	0	

Again calculate the remaining A (=which must equal the activity of X-103)

Take natural logarithm, plot vs time, get line with slope = $-\lambda_{X-103}$.



λ_{X-103} = 0.14 => $t_{½, X103}$ = 4.95 h.